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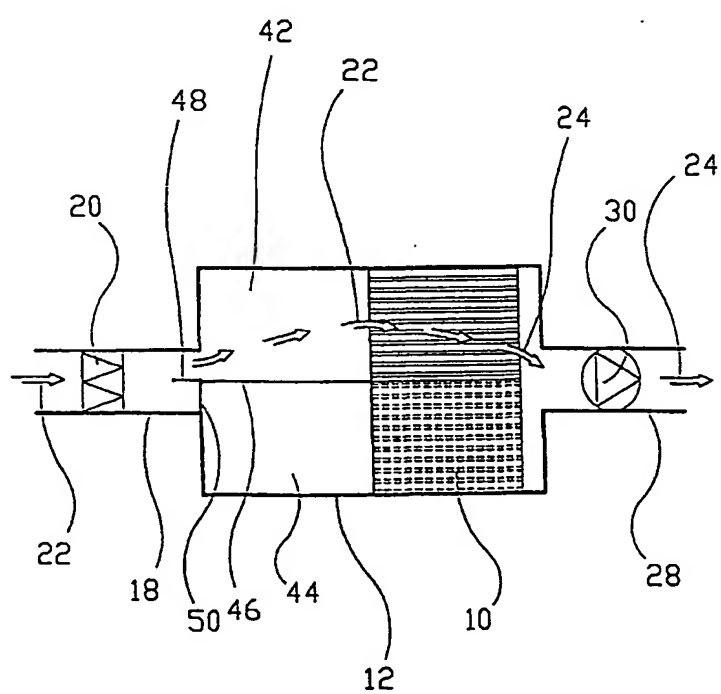
(54) Title: METHOD AND AGGREGATE FOR VENTILATION USAGE RELATED TO HEAT RECOVERY



(57) Abstract: There has been described a method of defrosting a heat-exchanger (10) of the counter-flow type, whereby outdoor air (22) is brought to flow into and through the heat-exchanger (10) in a first direction, while extracted air is brought to flow into and through the heat-exchanger (10) in a second opposite direction, so that the outdoor air leaves the heat-exchanger in the form of preheated supply air (24). In order to defrost a frosted heat-exchanger (10), while at the same time maintaining full supply of preheated supply air (24) to the room which is to be ventilated, the heat-exchanger (10) is defrosted regionwise, i.e. one region, for example one half, at a time. A supply pipe (18) for outdoor air (22) is arranged to two chambers (42, 44) positioned immediately upstream of the heat-exchanger (10) and arranged to allow individual closing/opening. In a first defrosting operation one chamber for outdoor air is closed (for example (44) by means of a damper (50)) so that all transportation of supplied outdoor air takes place through the second chamber (42) and one heat-exchanger section in the extension of the active chamber (42) for outdoor air. The extracted air flows through the whole heat-exchanger (10) during this and a subsequent defrosting operation, in which the so far inactive chamber (44) for outdoor air carries the entire flow of outdoor air, while the chamber (42) active during the first defrosting operation, is closed.

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METHOD AND AGGREGATE FOR VENTILATION USAGE RELATED TO HEAT RECOVERY

This invention relates to a ventilation method in connection with heat recovery, wherein preferably a counter-flow exchanger is used as heat-exchanger, whereby possibly filtered outdoor air is brought into forced flow in a first direction, while possibly filtered, extracted air is brought into forced flow through the counter-flow exchanger in a second direction, wherein the first and second directions may be opposite directions. By such a counter-flow heat-exchanger outdoor air will be guided into it at a first end thereof, whereas extracted air is guided into the counter-flow exchanger at its second opposite end.

Similarly, the invention relates to a ventilation and heat-recovery aggregate comprising a heat exchanger, preferably of the counter-flow type, in which provision has been made for the supply of outdoor air and forced flowing thereof through the separate outdoor air channels of the heat-exchanger during heat exchange with the similarly supplied extracted air flowing forcedly through and out of the separate

extracted air channels of the heat exchanger, whereby the exchanging of heat takes place through lamella-like partition walls separating the channels, and ensuring that said separate channels remain separate in a sealed manner, without any particular heat leakage to the surroundings.

After having passed through the counter-flow heat exchanger, the outdoor air enters the room in the form of supply air. After having given off some of its thermal energy in the heat-exchanger, the extracted air is vented to the atmosphere above roof level.

Thus, each of the two air flows passes through a number of parallel channels in the heat-exchanger, of which some, for example every second one, are arranged exclusively for the passage of outdoor air, whereas the others are arranged exclusively for extracted air to pass.

Thereby the outdoor air channels of the counter-flow heat-exchanger are separated completely form its extracted air channels, usually by means of spaced apart channel-defining lamellas or other sheets, whose walls serve as thermal transmission means. The advantage of heat recovering units of the counter-flow type is their great thermal efficiency. Also, these heat exchangers are secured against transmission of smell from out-flowing extracted air to incoming outdoor air. The individual channels are laterally tight towards adjacent channels, and outdoor air and extracted air each have an efficient filter arranged thereto, both filters being placed upstream of the heat-exchanger.

Rotating heat-exchangers do exist, but they have a lower efficiency than heat-exchangers working according to the counter-flow principle. Moreover, by rotational heat

exchangers there is a risk of smell and bacteria being transferred between incoming and outgoing air flows.

In ventilation and heat-recovery aggregates according to the invention the aim has been, among other things, economic advantages, as the use of low-energy motors as fan motors should be possible. Besides, each fan motor should be arranged so that it works as a sensor responding to the load that the motor is subjected to at any time, this response allowed to be utilized then for the registration of one out of two specific conditions of the heat exchanger: (1) That the heat-exchanger has been subject to formation of frost and should/has to be defrosted, or (2) that a filter (for example the outdoor air filter) has become so dirty that it presents a partially clogged/air-flow-limiting state. Experience shows that exchange of filter takes place approximately once a year, and this aspect of the invention is consequently less critical than the registration of the fact that the heat-exchanger has been subjected to frost formation.

In ventilation aggregates/apparatus/plants in for example family houses, flats, offices etc. the aggregate could be computerized, as the aggregate may be arranged to control the maintenance of a constant amount of air through the heat-exchanger.

Heat-exchangers of the counter-flow type are often subject to formation of frost to the extent of full clogging, whereby the passage of air is obstructed and the heat-exchanger can no longer function.

Frost formation in heat-exchangers of this kind occur when warm, moist extracted air is cooled by cold outdoor air.

Frost formation could normally occur by outdoor air temperatures of -5 °C and below.

Know defrosting technology consist in melting the ice and frost on/in the heat-exchanger, either when provisions are made for not letting through cold outdoor air during the defrosting/thawing, or by then making use of a preheating battery, but none of these solutions are considered satisfactory, especially not from an energy economic point of view.

Thus, earlier one has had to stop the air supply fan for the defrosting of the heat-exchanger or make use of a preheating battery, which heats the outdoor air before it enters the heat-exchanger during the defrosting period.

The object of the present invention is to prescribe a more advantageous method of defrosting heat exchangers, and suggest a practical constructional configuration of a ventilation and heat-recovery aggregate for the implementation of this method. Otherwise, the aggregate should be in accordance with the introductory part of Claim 2.

Said object are realized in the way specified in the characterizing part of Claim 1, or by said aggregate exhibiting the features appearing from the characterizing part of Claim 2.

In accordance with the method according to the present invention, a frosted heat-exchanger of the counter-flow type is defrosted regionwise, for example in two defrosting regions in separate defrosting operations, namely first in one region of the heat-exchanger and immediately after that,

in the other area, where preferably half the heat-exchanger being defrosted in each operation, while that half, which is not being defrosted, has the flow of all the outdoor air supplied, while at the same time full flow of extracted air is maintained, and this last-mentioned flow is the one that provides defrosting in one half of the heat-exchanger at a time.

By the aggregate according to the invention, the supply pipe for outdoor air has two chambers for outdoor air arranged thereto, placed immediately upstream of the heat exchanger, each chamber being provided with a shutoff damper and connected to a respective half of the heat-exchanger block. Normally both these dampers are in an open state, so that outdoor air from both chambers are supplied simultaneously to the respective halves of the heat-exchanger block to flow through it simultaneously. The outdoor air channels through the heat-exchanger block are thus kept separate from each other in a sealed manner by a partition wall extending in the direction of flow of the outdoor air through the block. The through-going channels for extracted air do not have such a division.

When defrosting of a frosted heat-exchanger block in a ventilation aggregate with heat-recovery is to be carried out, one damper arranged to one outdoor air chamber is activated first for the closing of said chamber to outdoor air supplied, whereby the heat-exchanger block receives all the incoming outdoor air supplied, through the second chamber, whose damper is in the open position.

Once defrosting of one half of the heat-exchanger block has been detected, the damper, which has been in the open position till now, is closed, whereas the closed damper is

opened. Thereby the incoming outdoor air is supplied to the heat-exchanger block through the outdoor air chamber which was recently closed, but whose damper has now been brought into its open position. Full flow through the heat-exchanger of warm extracted air is maintained during the defrosting operation, which may take about 40 minutes for the whole heat-exchanger.

By means of electronics incorporated in the supply air fan motor and the extracted air fan motor, and control automatics for the ventilation aggregate with heat-recovery, the defrosting function works in the following way:

The ventilation aggregate is arranged to maintain constant a preset amount of air. As frost is forming in/on the heat-exchanger and the latter may be about to become completely frosted, the pressure fall across the heat-exchanger increases and the rotational speed of the fan motor increases to maintain said constant amount of air. The increase/change in the rotational speed is utilized to output a signal to said dampers, which are supported individually movable in the outdoor air inlet, immediately upstream of the heat-exchanger.

A major increase in the pressure fall, occurring within about 24 hours, indicates that there is frost in the heat-exchanger block.

Moreover, measured intern pressure fall is also considered an indication and a reminder that the filter(s) should be exchanged. In this case there will be a steady increase in the pressure fall over a longer period of time. In the period of time, during which the filters are gradually becoming dirty, the pressure fall steadily building will provide a

signal, so that the rotational speed of the fan engine is increased and the constant amount of air maintained, i.e. the fan capacity increases when the filters are becoming dirty. Thus, between filter replacements correct amount of air through the aggregate will be ensured. The great efficiency of the heat-recovery unit normally makes the use of an after-heating battery redundant.

A non-limiting example of a preferred embodiment is described in further detail in the following, referring to the accompanying drawings, in which the figures show the ventilation aggregate in the area of the heat-recovery unit in a highly schematic presentation, the numbered arrows showing the directions of the different air flows, and in which:

Fig. 1 represents a vertical sectional view, in which a heat-exchanger of the counter-flow type is symbolized by a rhombus-like circumference, and in which a chimney cowl is represented as an inverted V to show that extracted air, which has passed through the heat-exchanger and given off an essential part of its thermal energy there, is let out to the atmosphere at a level above roof level;

Fig. 2 shows generally the same as Fig. 1, but in an external side view, and with an indication of a particular section III - III (for Figs. 3, 3A and 3B);

Fig. 3 shows a horizontal section along the line III - III in Fig. 2, in which two outdoor air chambers placed immediately upstream of the heat-exchanger have a shutoff damper each, arranged thereto, which are in the open state, so that outdoor air from both chambers is flowing through the heat-exchanger;

Fig. 3A corresponds to Fig. 3, but here the damper of one outdoor air chamber is brought into its closed position, so that the outdoor air supplied, passes exclusively through one half of the heat-exchanger through the second outdoor air chamber, after which it flows, as preheated supply air, through a channel with a supply air suction fan into the room;

Fig. 3B corresponds to Fig. 3A, but here there is a damper of another outdoor air chamber, which is in its closed position, so that supplied, filtered outdoor air is brought to flow exclusively axially through the second half of the heat-exchanger, as compared to Fig. 3A, the heat-exchanger being open over its entire effective cross-section to the warm extracted air, so that this can flow through while giving off heat;

Fig. 4 shows an end view from the left-hand side according to the arrow IV in Fig. 2; and

Fig. 5 shows an end view from the right-hand side according to the arrow V in Fig. 2.

A heat recovery unit of the counter-flow type, which is symbolized by a rhombus-like circumference, is identified by the reference numeral 10, and enclosed by a housing 12, short partition walls 14 an 16 extending between the inner surfaces of the walls of the housing 12 and two opposite corners of the heat-exchanger 10, as appears from Fig. 1.

To the housing 12 a channel 18 for outdoor air is connected, provided with a filter 20.

The outdoor air, arrow 22, passes through outdoor air channels extending through the heat-exchanger in a heat-exchanging relation to warm extracted air, flowing at the same time in the opposite direction through the heat-exchanger, via the walls of the lamella or similar sheets, of which the heat-exchanger is built.

Preheated supply air is identified by 24. The flow of the extracted air is identified by arrows 26.

From the housing 12, round the heat-exchanger block 10 a channel 28 for preheated supply air 24 is connected, in which the supply air fan 30 is mounted. The extracted air 26 enters the housing 12 from an extraction channel 32 with a filter 34, and leaves the housing 12 through an extraction channel 36 with an extraction fan 38. As stated earlier, the chimney cowl 40 indicates that the extracted air, with reduced thermal energy, is vented to the atmosphere above roof level.

Fig. 3 shows a horizontal section along the section line III - III in Fig. 2 It appears that the channel 18 for the supply of outdoor air is connected downstream of two coordinate chambers 42 and 44 for outdoor air, a partition wall between the chambers 42, 44 being identified by 46.

In the transition area between the outdoor air channel 18 and each of the chambers 42, 44 is arranged a pivotal shutoff damper 48, 50, respectively. In Fig. 3 the dampers 48, 50 are bearing on one another and therefore do not appear as two separate dampers. The dampers 48, 50 are operated by a damper motor 51.

According to Fig. 3, the arrows 22 and 24, corresponding to the reference numerals in Fig. 1, show the passage of the outdoor air flow through the heat-exchanger.

The heat-exchanger 10 may be divided, for example by a middle partition wall, into separate coordinate sections for parallel through-going channels, which are reserved exclusively for the flow of outdoor air, whereas the parallel channels in between, which are meant exclusively for the flow of the extracted air, are not divided in a corresponding manner. Thus, the extracted air flows through the entire cross-section of the heat-exchanger in the through-going parallel channels reserved for the flow of extracted air.

When the outdoor air temperature is low, for example -5 °C and lower, incoming outdoor air in connection with warm, moist extracted air will result in frost formation on/in the heat-exchanger, which will consequently have to be defrosted. In cold weather it may be necessary to defrost, for example once every 24 hours.

As mentioned, the ventilation aggregate is arranged to maintain constant a preset amount of air. When frost is forming in/on the heat-exchanger, the pressure fall across it, and the rotational speed of the fan motor increases to maintain a constant amount of air. This increase in rotational speed is utilized so, that said damper 50 or 48 is activated and is turned in order to close the passage of the outdoor air into the outdoor air chamber 42, Fig. 3A, or into the outdoor air chamber 44, Fig. 3B.

Figs. 3A and 3B represent the two consecutive partial defrosting operations. From its position shown in Fig. 3, the damper 50 is turned so that the chamber 44 does not receive

outdoor air, as all the outdoor air supplied is sucked through the half of the heat-exchanger 10 located correspondingly.

The fact that the outdoor air 22 in this case, Fig. 3A, is supplied asymmetrically to the upstream end of the heat-exchanger would be a sufficient measure for orienting the flow of outdoor air so that it stays in the left-hand half of the heat-exchanger 10 through the whole axial length of the heat-exchanger; cf. the arrows 22 and 24.

Of course, the same applies to Fig. 3B. Thus, it is not absolutely necessary for the heat-exchanger 10 to be equipped, in all embodiments of the invention, with an internal partition wall aligned with the partition wall 46 and separating the parallel channels, which extend through the heat-exchanger and are reserved for supply air.

On the other hand, the extracted air should in any case flow through the full cross-section of the heat-exchanger 10, referring to the separate parallel through-going channels for the extracted air, said channels being separated in a sealing manner from the corresponding channels for the outdoor air.

Figs. 3A and 3B show how a frosted heat recovery unit of the counter-flow type is defrosted in two operations. Extracted air 26, see Fig. 1, flows at any time through the heat-exchanger 10 from right to left, and its thermal energy provides defrosting of that half of the heat-exchanger, which has no outdoor air flow at any time during the defrosting.

At all times during these defrosting operations, it is the part(s) of the heat-exchanger, through which no outdoor air is passing, that is (are) defrosted by means of the extracted

air. After the damper 50 has been closed during the first defrosting operation (Fig. 3A), the programmed electronics incorporated in the fan engines take care of bringing this damper 50 into its open position, and closing the damper 48 at the same time, whereby the flow of the supply air (22 and 24) proceeds as indicated in Fig. 3B, while the defrosting now takes place in the second half of the heat-exchanger 10, through which no outdoor air is passing.

The initiation of the defrosting is preferably based on the increase in pressure fall mentioned above, and a major increase in the pressure fall happening within 24 hours indicates that there is frost in the exchanger block, and that the exchanger block is about to become frosted and functionally deteriorated. The implementation of the defrosting can also be initiated on signals from temperature sensors, by the use of a timer etc.

Moreover, such measuring of internal pressure fall can be utilized to indicate functional deterioration of the filters and as a reminder that the filter(s) should be replaced.

Dirtied/failing filters causes the increase in the pressure fall to be steady over a longer period of time. At the point when the filters have become soiled, the pressure fall that is steadily building up, will provide signals to cause an increase in the rotational speed of the fan engine and maintenance of the constant amount of air.

C l a i m s

1. A method of defrosting a heat-exchanger (10), preferably of the counter-flow type, incorporated in a ventilation aggregate, in which outdoor air (22) is brought to flow through the heat-exchanger (10) in a first direction, while extracted air (26) is brought to flow through the heat-exchanger (10) in the opposite direction, and in which the heat-exchanger (10) is defrosted periodically, by low outdoor temperatures, by means of the extracted air, c h a r a c - t e r i z e d i n that the heat-exchanger (10) is defrosted regionwise, for example one half at a time, the outdoor air (22) being brought to flow through said half of the heat-exchanger in a first defrosting operation, followed by a second corresponding defrosting operation, while the extracted air is flowing - in a manner known in itself - through the heat-exchanger (10) in its entire cross-section all the time during the defrosting.

2. A method as claimed in Claim 1, c h a r a c t e r i z e d i n that supplied outdoor air (22) is filtered before it by defrosting being brought into forced flow through one out of two heat exchanger sections arranged one beside the other with parallel channels extending therethrough, formed exclusively for the flow of outdoor air, and that after the defrosting of the first heat exchanger section, the supplied outdoor air (22) is brought into forced flow through the section of the heat-exchanger where only extracted air was flowing during the first defrosting operation.

3. A ventilation aggregate comprising a heat-recovery unit (10) preferably of the counter-flow type, a supply pipe (18) for outdoor air (22) at a first side of the heat-exchanger

for outdoor air (22) at a first side of the heat-exchanger (10), and a supply air pipe (28) with a supply air fan (30) on the opposite side of the heat-exchanger (10), a pipe (32) for extracted air on said opposite side of the heat-exchanger (10) and with a discharge pipe (36) for extracted air on said first side of the heat-exchanger, characterized in that upstream of the heat-exchanger (10), the supply pipe (18) for outdoor air (22) has two closable/openable chambers (42, 44) for outdoor air arranged thereto, which are arranged either to be kept open simultaneously or - during defrosting - so that one outdoor air chamber (for example 44, Fig. 3A, or 42, Fig. 3B) is closed, whereby all outdoor air supplied is oriented so that it flows forcedly through only a first area, for example one half, of the heat-exchanger (10), after which a second area, for example a second half located beside the former and with the same direction of flow as that, is brought to receive the entire flow of outdoor air.

4. A ventilation aggregate as claimed in Claim 3, characterized in that opposite outdoor air supplied, the inlet of each chamber (42, 44) for outdoor air is provided with a shutoff valve in the form of a pivotal damper (48, 50), preventing, in its closed position, outdoor air from entering the associated chamber.

5. A ventilation aggregate as claimed in claim 3 or 4, characterized in that the supply pipes (18 and 32, respectively) for outdoor air (22) and extracted air (26), respectively, to the heat exchanger (10) are provided with filters (20 and 34, respectively), and that the aggregate is equipped with means for measuring internal pressure fall, providing a reminder that filter(s) should be replaced, if a steady increase in pressure fall is registered

over a longer period of time, this pressure fall (as opposed to indication of frost in the heat-exchanger block, which shows itself through a major, brief increase in pressure fall) building up steadily by gradual soiling of the respective filter, providing a signal, so that the rotational speed of the fan motor increases in order to maintain constant the amount of air through the aggregate.

6. A ventilation aggregate as claimed in claim 3, c h a - r a c t e r i z e d i n that the heat-exchanger block (10) is divided into two or more parts positioned one beside the other with the same direction of flow for outdoor air (22).

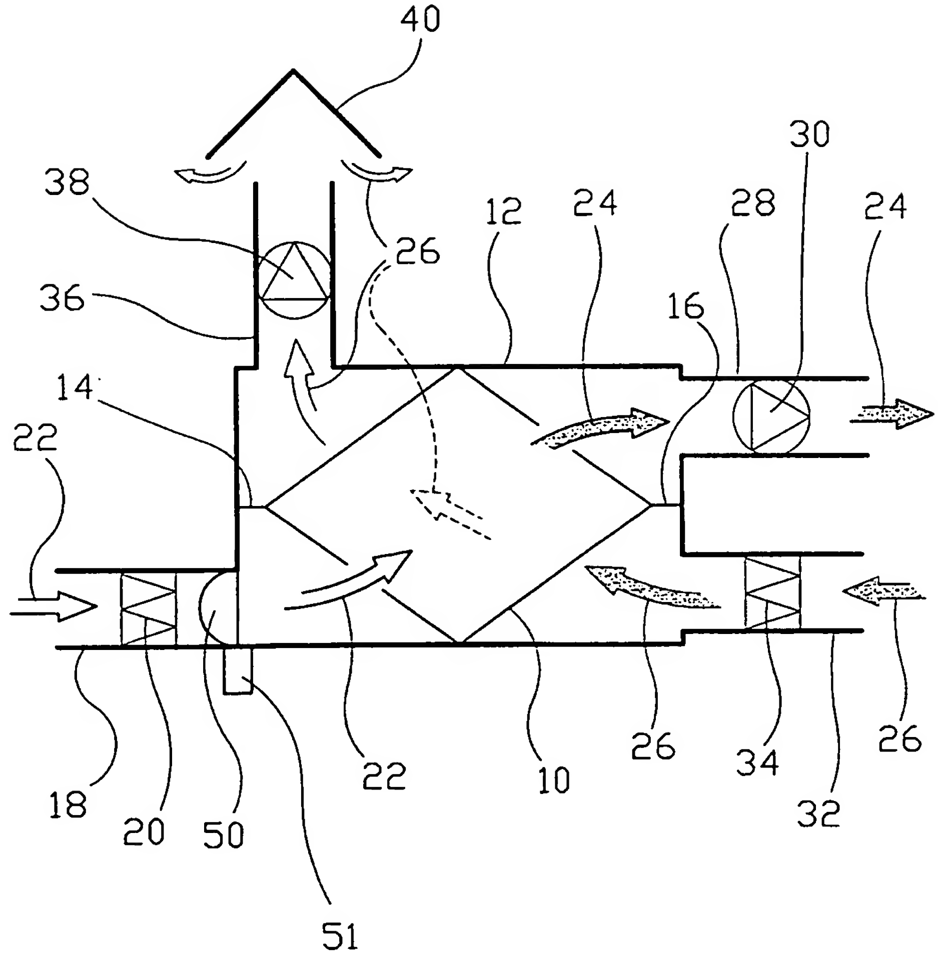

FIG. 1

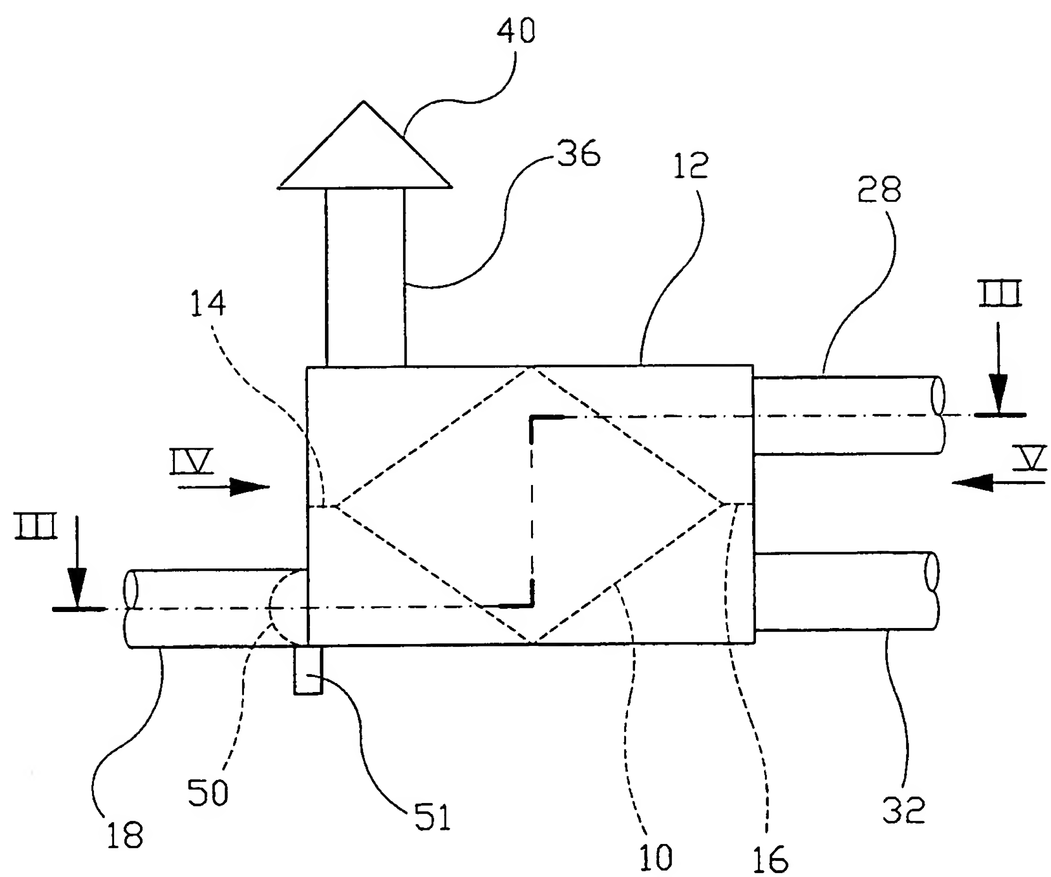

FIG. 2

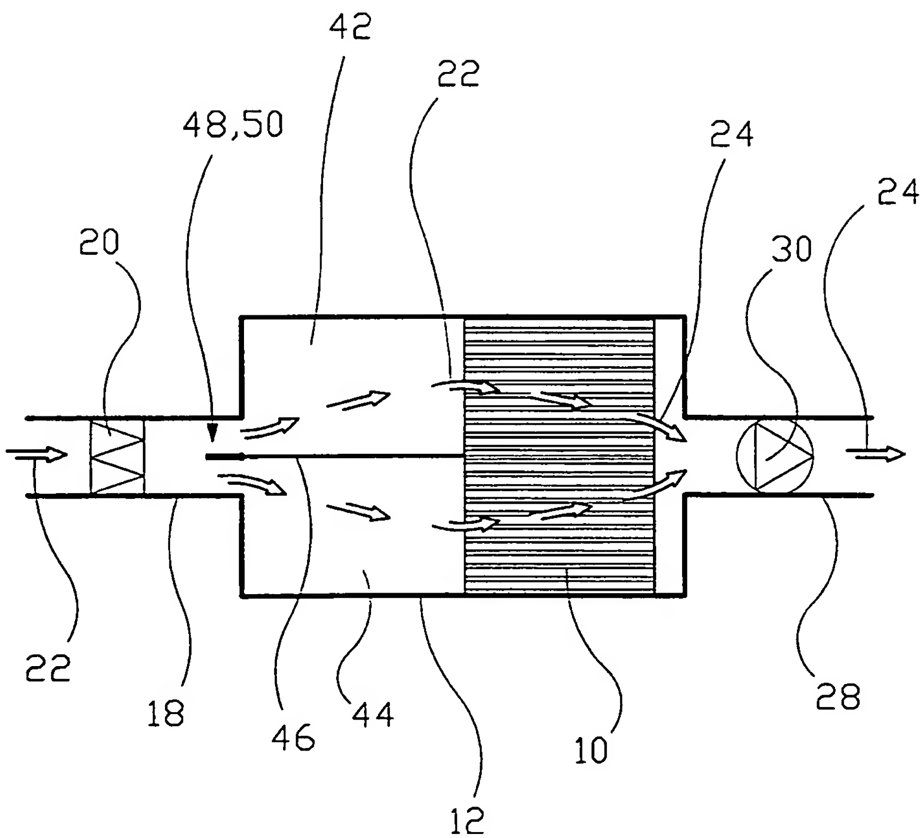

FIG. 3

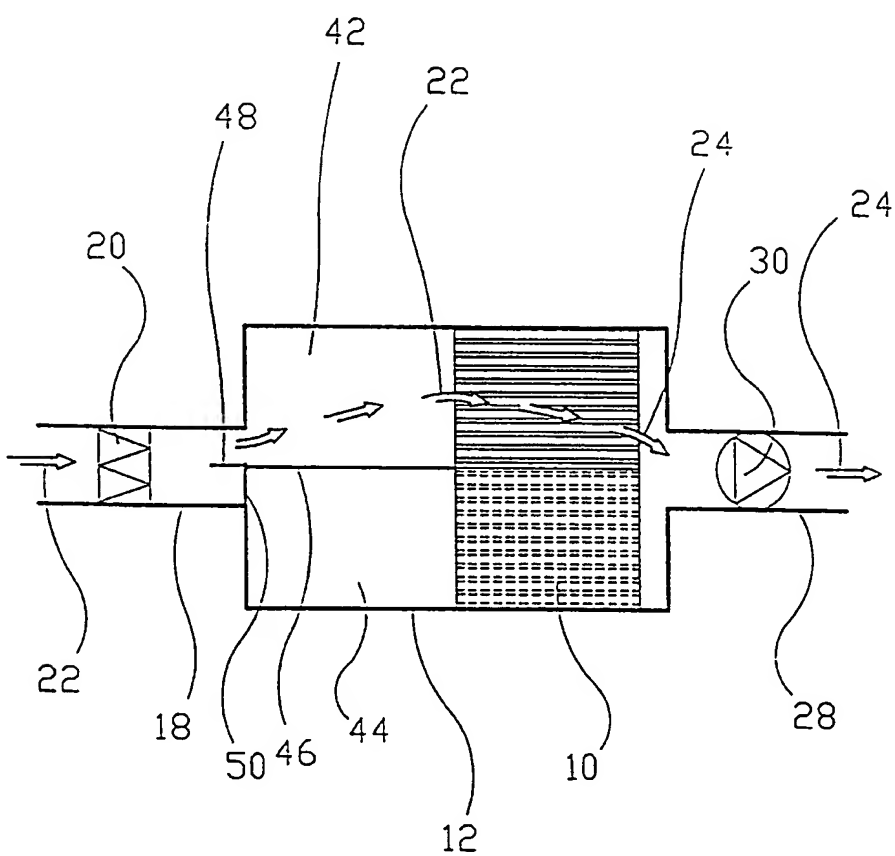

FIG. 3A

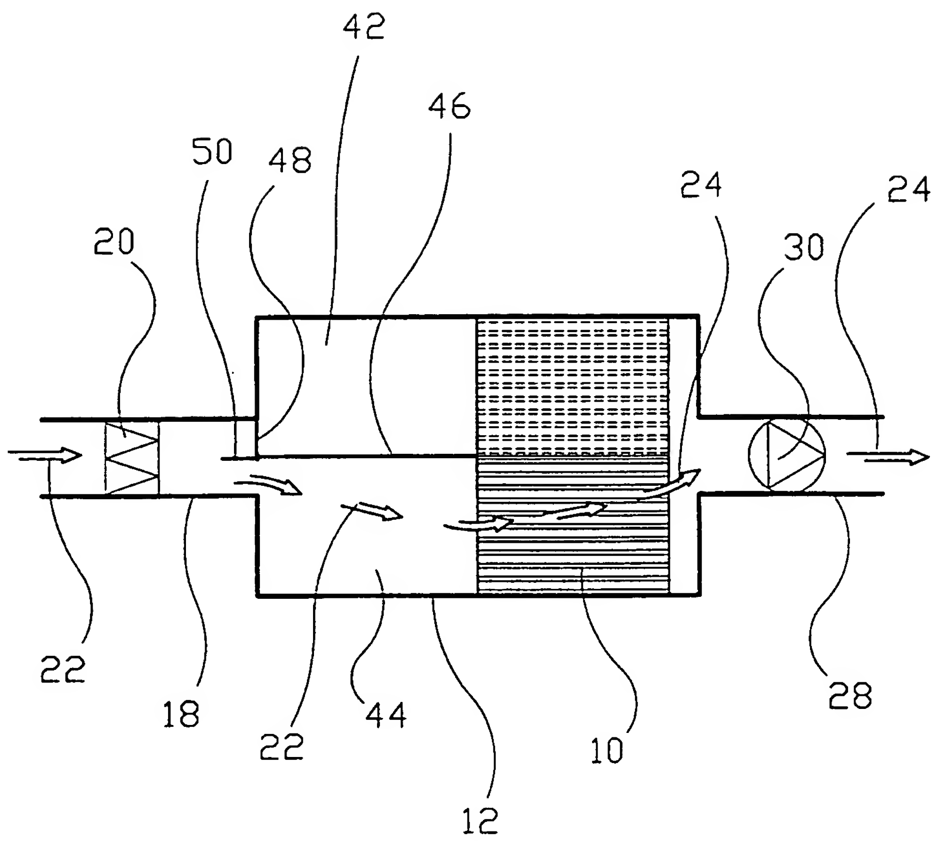

FIG. 3B

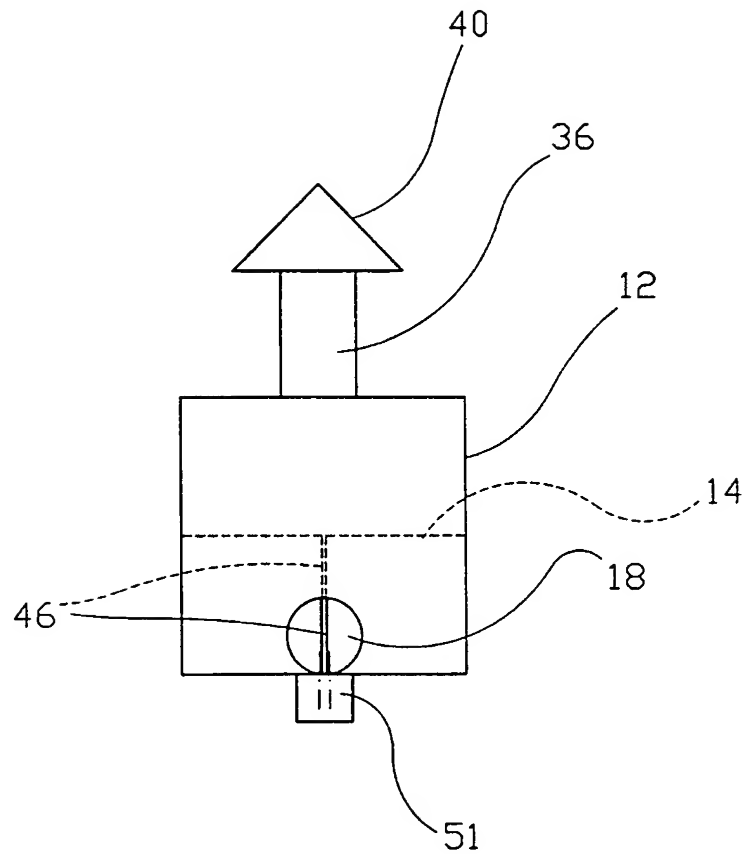

FIG. 4

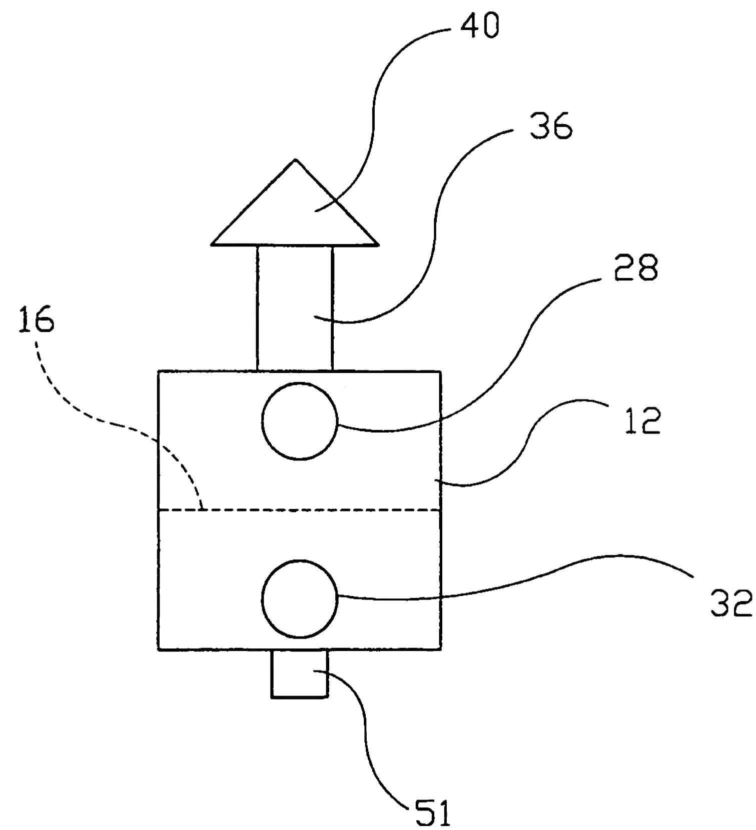

FIG. 5

INTERNATIO[redacted]L SEARCH REPORT

Inter[redacted]pplication No.
PCT/N[redacted]/00305

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F28F 27/02, F24F 12/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F28F, F24F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4971137 A (THOMPSON), 20 November 1990 (20.11.90), column 7; column 2, figure 5 --	1-4
X	SE 463944 B (STRATOS VENTILATION PRODUKT AB), 11 February 1991 (11.02.91), page 6, line 28 - line 37; page 7, line 26 - line 35; page 8, claims 1,10 --	1-6
A	Patent Abstracts of Japan, abstract of JP 1-137139 A (MATSUSHITA SEIKO CO LTD), 30 May 1989 (30.05.89), see abstract, figures --	1-6

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
3 January 2001	08 -01- 2001

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

04/12/00

International Application No.
PCT/NO 00/00305

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				DK	168773	B	06/06/94
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